

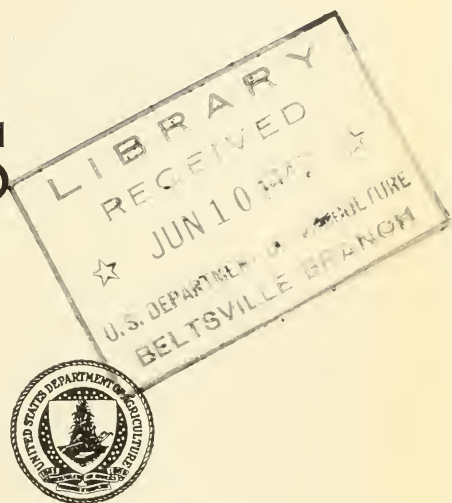
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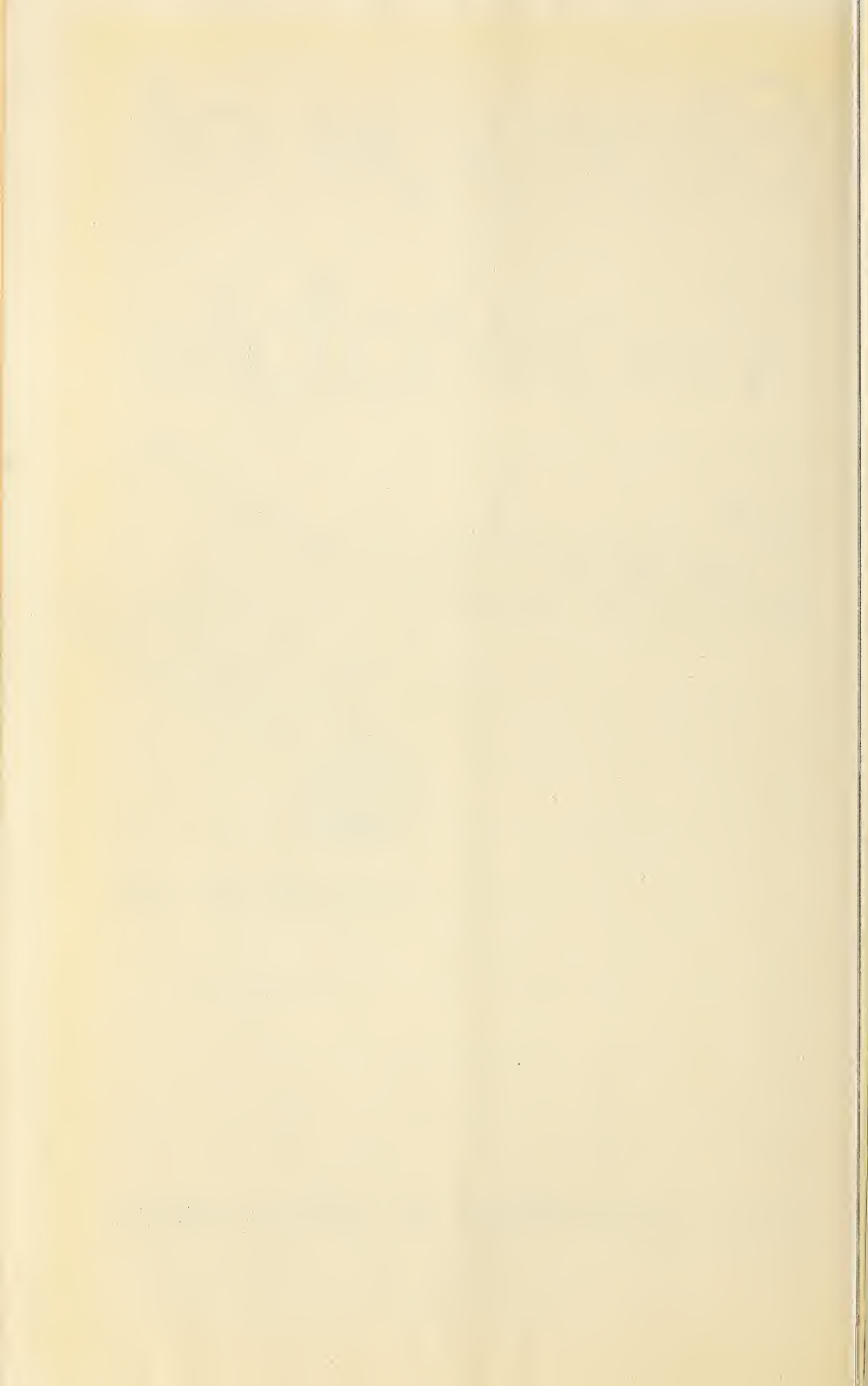
# Storage of Vegetable Seeds



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# STORAGE OF VEGETABLE SEEDS

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## Importance of Conserving Seed Supplies

Under present world conditions it is necessary that the supplies of vegetable seeds be conserved for the growing needs of our own country and of others dependent on us for vegetable seeds. It is even more important than usual that there be no unnecessary depletion of stocks resulting from loss of viability due to unfavorable conditions during storage and transportation. This leaflet presents a brief summary of what has been learned from experiments conducted by the Division of Fruit and Vegetable Crops and Diseases on the factors that influence the viability of seeds during storage. The recommendations given are not final but conform to the best information available at present. Further details about the storage of vegetable seeds may be obtained from other publications of the Department, many of which may be found in libraries. Two of interest on this subject are here indicated.<sup>1</sup>

## General Principles of Seed Storage

It must be remembered that a seed is largely made up of living material and that any injury that prevents later development of a normal seedling destroys the value of the seed for crop production. The life processes of a stored seed are very much reduced in intensity in comparison with those of a growing plant. However, increase of seed moisture increases the life activity of the stored seed even though the moisture content is far below that required for active growth or germination. Increase of temperature also increases this life activity. Not much is known about the actual processes leading to the death of seeds, but it would appear that as these life activities take place in storage the living material is gradually weakened and complete loss of viability finally results. These general considerations make it clear that increased moisture in the seed speeds the changes that finally lead to loss of viability, that increased temperature further increases the rate of these changes, and that any exposure to high temperatures and high moisture reduces the potential duration of life of seeds, even before the percentage of germination is reduced. Weakening of seed may result from unfavorable conditions during ripening on the plant (fig. 1), during harvesting, or during curing immediately after harvest; therefore age of seed from harvest may not be a measure of ability to withstand further storage.

The length of time that seeds will be stored must also be considered. Storage for 3 months at a given condition might not seriously affect

<sup>1</sup> BEATTIE, J. H., and BOSWELL, VICTOR R. LONGEVITY OF ONION SEED IN RELATION TO STORAGE CONDITIONS. U. S. Dept. Agr. Cir. 512, 23 pp. 1939.

BOSWELL, VICTOR R., TOOLE, E. H., TOOLE, VIVIAN K., and FISHER, D. F. A STUDY OF RAPID DETERIORATION OF VEGETABLE SEEDS AND METHODS FOR ITS PREVENTION. U. S. Dept. Agr. Tech. Bul. 708, 48 pp., illus. 1940.

germination, whereas extending the period of storage to a year might lead to marked loss of viability.

Life activity of the seed is very low at low temperatures or when the seed moisture is low. Little difficulty is found in keeping seeds in cool northern climates; also, seed viability may be maintained a long

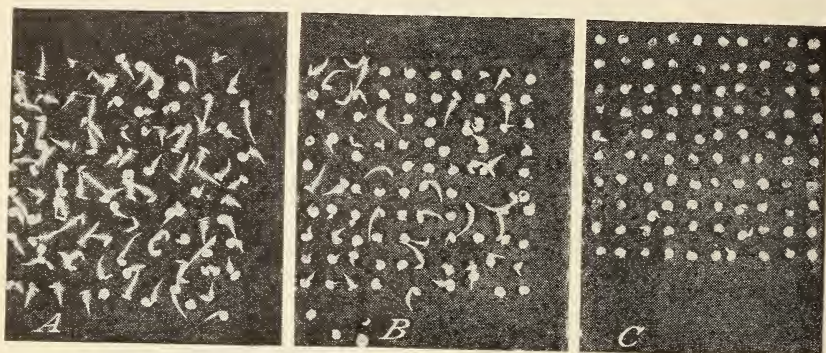


FIGURE 1.—Differences in seed vigor at time of harvest as indicated by germination at end of 6 days. Each blotter has seed from a separate well-developed fruit of Long Thick Cayenne pepper. Final germination after 14 days was 100 percent for A, 97 percent for B, and 26 percent for C.

time in the dry Southwest in spite of high temperatures. Seeds lose viability very rapidly in the humid South and Southeast, and unexpected heavy losses of viability may occur in any region if the moisture content of the seed is too high for the temperature of storage.

### Moisture Changes of Seeds

Seeds take up moisture from or give it off to the surrounding air until equilibrium with the surroundings is reached. The moisture content attained by seeds depends largely on the relative humidity of the surrounding air and does not vary greatly with temperature at a given relative humidity. Seeds come to moisture equilibrium with the immediately surrounding air comparatively quickly, although the rate varies with the size and kind of seed. Therefore moisture changes in a bulk of seeds depend on the relative humidity of the air and the movement of air around the seeds. Different kinds of seeds reach different moisture contents in air of the same humidity.

Because of the importance of seed moisture in the storage of seeds, it is important to know approximately the moisture content that different kinds will reach when stored at any given air humidity. Rough approximations of moisture equilibriums for several kinds of vegetable seeds at different relative humidities of air are given in table 1. Although these values are based on moisture determinations of seeds stored under controlled experimental conditions, they should be considered approximate rather than exact values. For kinds of seeds not listed comparative values can be estimated from related kinds. For example, no exact information is available for cauliflower or leek seed, but it is probable that the moisture relations of these seeds are very similar to those of cabbage and onion, respectively.

TABLE 1.—*Estimated moisture contents of seed (fresh basis) attained at different relative humidities of air*

Kind of seed	Estimated moisture content of seed stored at relative humidity of—				Kind of seed	Estimated moisture content of seed stored at relative humidity of—			
	45 per-cent	65 per-cent	73 per-cent	80 per-cent		45 per-cent	65 per-cent	73 per-cent	80 per-cent
	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>		<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>	<i>Pct.</i>
Bean, kidney-----	9.0	12.0	14.0	16.0	Okra-----	10.0	12.0	13.0	14.5
Bean, lima-----	9.0	12.0	14.0	15.0	Onion-----	9.0	11.0	12.0	13.5
Beet-----	6.5	10.0	12.5	15.0	Pea, garden-----	9.0	12.0	13.5	15.5
Cabbage-----	6.0	8.0	9.0	10.0	Peanut (shelled)-----	4.5	6.0	7.0	8.0
Carrot-----	7.5	10.0	11.0	12.5	Pepper-----	7.5	9.5	10.5	12.0
Celery-----	9.0	11.0	12.0	13.5	Spinach-----	10.0	12.0	13.0	14.5
Corn, sweet-----	9.0	11.0	12.5	14.0	Tomato-----	8.0	10.0	11.0	12.0
Cucumber-----	7.0	8.5	9.0	10.0	Turnip-----	6.0	8.0	9.0	10.0
Lettuce-----	6.0	8.0	9.0	10.0	Watermelon-----	7.5	9.0	10.0	11.0

### Maintaining Seed Viability

All gardeners know that some kinds of seeds keep better than others. Many gardening books list the number of years different vegetable seeds will maintain their viability. Such lists serve as general guides, but with any specific lot of seed it must be remembered that original vigor or vitality and temperature and moisture during storage are much more important than age alone in determining the value of the seed.

#### Rapid Deterioration at High Humidity and High Temperature

It is not generally realized how quickly seeds may deteriorate under conditions that are often encountered in the continental United States. In recent experiments a sample of onion seed with an original germination of 94 percent, when stored at 80° F. and 80 percent

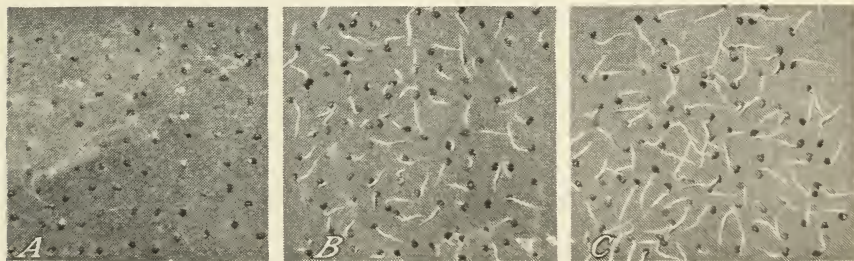


FIGURE 2.—Germination of onion seed after storage at controlled conditions for 12 weeks: A, At 80° F. and 80 percent humidity; B, at 80° and 66 percent humidity; C, at 50° and 50 percent humidity.

humidity, decreased 12 percent in germination in 3 weeks and showed no germination after 12 weeks (fig. 2). The moisture content during storage was 13.2 percent. After storage at this condition for 9 weeks the particular samples of onion, sweet corn, shelled peanut, and celery seeds used in the experiments were worthless for planting purposes, and there was appreciable to serious loss of viability by carrot, water-

melon, spinach, cabbage, pepper, lettuce, okra, cucumber, and turnip seeds; only bean, beet, pea, and tomato seeds showed no definite decrease in germination in 9 weeks. Temperatures of 80° and higher and humidities approaching 80 percent may prevail in storage rooms for many weeks in the South Atlantic or Gulf Coast areas and for shorter periods in other areas.

It might seem desirable to present estimates of the duration of safe storage for the different kinds of vegetable seeds at high temperature and high humidity. Although the relative loss of viability of the different kinds of seeds stored at these adverse conditions is known, the exact rate of loss would be influenced by the previous weakening of seed vitality by conditions during harvesting or early storage.

#### Low Humidity Essential at High Temperature

Seeds that are to be subjected for more than a few days to temperatures near 80° F. should be stored at a relative humidity not above 45 percent or protected to maintain a seed moisture content characteristic of 45 percent humidity storage (see table 1). The more sensitive kinds of seed, such as onion, peanut, celery, and sweet corn, should be kept even drier than this. At an average temperature of 70° a relative humidity of air of 60 percent or the equivalent seed moisture content should be maintained for seeds not especially sensitive to storage conditions.

#### Recommended Seed Moistures for Different Temperatures

A good record of the relative air humidity of the storage room, together with the data in table 1, furnishes a fair indication of what the seed moisture will be. However, the surest way to find whether seeds are stored dry enough for safety at the prevailing temperature is to make moisture determinations on properly drawn samples of each kind of seed.

Estimated maximum safe seed moisture contents of different kinds of vegetable seeds for satisfactory storage for a year are given in table 2.

TABLE 2.—*Estimated maximum safe seed moisture contents for storage for 1 year at different mean temperatures of storage (approximate guide only)*

Kind of seed	Maximum safe seed moisture content for average temperature of storage indicated			Kind of seed	Maximum safe seed moisture content for average temperature of storage indicated		
	40°-50° F. <sup>1</sup>	70° F.	80° F.		40°-50° F. <sup>1</sup>	80° F.	80° F.
	Percent	Percent	Percent		Percent	Percent	Percent
Bean, kidney	15	11	8	Okra	14	12	10
Bean, lima	15	11	8	Onion	11	8	6
Beet	14	11	9	Pea, garden	15	13	9
Cabbage	9	7	5	Peanut (shelled)	6	5	3
Carrot	13	9	7	Pepper	10	9	7
Celery	13	9	7	Spinach	13	11	9
Corn, sweet	14	10	8	Tomato	13	11	9
Cucumber	11	9	8	Turnip	10	8	6
Lettuce	10	7	5	Watermelon	10	8	7

<sup>1</sup> Special precautions needed when removed to higher temperature. (See section on Cold Storage of Seed, p. 6.)

### Holding Over Seed Stocks

It is often necessary to hold seeds left after one planting season for use the next. Seed lots that have decreased noticeably in viability or in rate of germination will show further loss very quickly unless kept at low moisture content at reasonably low temperatures. It must be remembered that, unless previous storage has been at very favorable conditions, this older seed will not keep as well as fresh seed of good vigor, even if the germination test does not show actual loss of viability.

Comparatively small lots of seed held by growers may be dried by exposing in thin layers in the open on a sunny dry day or in a normally heated room. The dried seed should be placed in an airtight container and stored in a cool place.

In tropical climates it has been found satisfactory to place the dried seed in sealed jars above, but not in contact with, a few ounces of calcium chloride or burned lime. Enough of the drying agent should be used to take up the excess moisture of the seed without apparent action on the drying material.

### Cold Storage of Seed

Cold storage is an obvious method of preserving the viability of seeds, but there are many things to take into consideration in connection with cold storage. Temperatures somewhat below freezing will not injure seeds unless their moisture content is unusually high. The storage temperature selected will depend on the facilities available and on the economy of operation. It is probable that a temperature of 50° F. is sufficiently low, provided humidity also can be controlled. It probably is not desirable to use temperatures below 40° because of expense of operation. High humidity at 40° to 50° is not as serious as at high storage temperatures. However, even at low temperatures contaminating fungi may develop at humidities approaching 80 percent and cause further injury to the seed. With the particular samples used in tests by this Division, the seeds of onion, sweet corn, celery, watermelon, and pepper showed appreciable loss of viability in 6 to 9 months when stored at 80 percent humidity at a temperature of 50°.

In addition, seed in cold storage at high humidities would have a high moisture content on removal. It has been found that seeds removed from cold storage with a high moisture content and subjected to high summer temperatures deteriorate so rapidly that in a few weeks the benefit of holding in cold storage may be lost.

Therefore, it appears that any temperature from 40° to 50° F. would be suitable, that an air humidity of 50 percent would be desirable, and that an air humidity of 70 percent should not be exceeded. Unless the seed is to be used at once after removal from storage, the moisture content should be determined and, if the moisture is above the safe limit for the expected temperature, the seed should be dried carefully to a safe moisture content.

It may often be feasible to provide moistureproof containers for storage of small lots of seed having a sufficiently low moisture content so that the air humidity of the storage room will not affect the seed. Seeds removed from cold storage should be allowed to reach normal temperatures in a place with low air humidity to avoid condensation of moisture on the cold seeds.

## Drying of Seed

Because special emphasis has been placed on low seed-moisture content for safe storage, some attention should be given to methods of drying seeds. Where air humidity is low and temperature moderate, seeds in sacks stacked to allow free circulation of air will dry out before any serious damage results. It may often be desirable to lower the moisture content more rapidly by the use of artificially heated moving air. It has been found<sup>2</sup> that seed of low vigor due to previous unfavorable storage was injured by drying in thin layers on screens for 3 hours in moving air at 150° F. but not at 120°. Seed of normal vigor was not injured at either temperature. Beans were dried from 16 to 13.5 percent moisture in 3 hours at 120° and onion seed from 13.5 to 7.5 percent moisture in ½ hour at the same temperature. Where original moisture is very high, as may be the case with freshly harvested seed, special precaution should be taken that seed temperature does not become high until the excess moisture is removed.

Within the range of moisture contents recommended here, there has been no evidence of poorer seedling growth resulting from low moisture content of the seed. However, it has been found that okra seed with 10 to 12 percent moisture germinated 3 to 4 days later than seed with 14 to 15 percent moisture. It is believed that there would be a marked increase of hard seed of okra and also of bean when the moisture is lowered to approximately 7 percent or lower.

## Summarized Recommendations

(1) For seeds exposed to a temperature of 80° F. for more than a few days the relative humidity of air should be no higher than 45 percent.

(2) For seeds exposed to 70° F. the relative humidity of air should be no higher than 60 percent.

(3) Very short-lived seeds, such as onion and shelled peanut, old seed, or seed contaminated by fungi should be kept at a lower humidity than is recommended above.

(4) For seeds in cold storage at 40° to 50° F., the relative humidity of air should be no higher than 70 percent and preferably should not be above 50 percent.

(5) Seeds removed from cold storage at a humidity above 50 percent should be dried to a moisture content safe for the temperature of later exposure, unless they are to be planted within a few days.

<sup>2</sup> See U. S. Dept. Agr. Tech. Bul. 708, cited in footnote 1.



